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Patent Application of: David Ben-Eli
Title: METHOD AND APPARATUS FOR SEARCHING FOR A BASE STATION USING AN ADAPTABLE SEARCH WINDOW
Attorney Docket No.: 884.647US1

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UNITED STATES PATENT APPLICATION

**METHOD AND APPARATUS FOR SEARCHING FOR A BASE STATION
USING AN ADAPTABLE SEARCH WINDOW**

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METHOD AND APPARATUS FOR SEARCHING FOR A BASE STATION USING AN ADAPTABLE SEARCH WINDOW

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BACKGROUND OF THE INVENTION

Mobile communicators within cellular communication systems are often required to search for and track one or more base stations within the system during normal operation. Often, a communicator will need to search for and track a number of different base stations simultaneously. As can be appreciated, these base station search functions can consume a significant amount of the computational and time resources of a mobile communicator. These functions may also consume energy resources within the mobile communicator (e.g., by depleting batteries within a handheld communicator). Therefore, there is a general need for base station search techniques and structures that are time, computation, and/or energy efficient.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating a mobile communicator in accordance with an embodiment of the present invention;

Fig. 2 is a block diagram illustrating functionality within a search receiver in accordance with an embodiment of the present invention;

Figs. 3 and 4 are portions of a flowchart illustrating a process for searching for a base station using an adaptable length search window in accordance with an embodiment of the present invention; and

Figs. 5 and 6 are portions of a flowchart illustrating a process for searching for a base station using an adaptable length search window in accordance with another embodiment of the present invention.

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DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings that show, by way of illustration, specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. It is to be understood that the various embodiments of the invention, although different, are not necessarily mutually exclusive. For example, a particular feature, structure, or characteristic described herein in connection with one embodiment may be implemented within other
10 embodiments without departing from the spirit and scope of the invention. In addition, it is to be understood that the location or arrangement of individual elements within each disclosed embodiment may be modified without departing from the spirit and scope of the invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the
15 appended claims, appropriately interpreted, along with the full range of equivalents to which the claims are entitled. In the drawings, like numerals refer to the same or similar functionality throughout the several views.

Fig. 1 is a block diagram illustrating a mobile communicator 10 in accordance with an embodiment of the present invention. The mobile communicator 10 may be
20 used, for example, within a code division multiple access (CDMA) based cellular communication system having a plurality of base stations that provide communication services to mobile users. The mobile communicator 10 may be implemented as any form of mobile communication device or subsystem including, for example, a cellular telephone, a personal digital assistant (PDA), a pager, a portable computer with
25 wireless transceiver functionality, and others. As illustrated, the mobile communicator 10 includes: a receive antenna 12, one or more communication receivers 14, 16 (RECEIVER A, RECEIVER B), a search receiver 18, a controller 20, a base station memory 22, and a user interface 24. Although not illustrated, transmitter functionality may also be provided. It should be understood that the individual blocks illustrated in
30 Fig. 1 (and other block diagrams described herein) are functional in nature and do not

necessarily represent discrete hardware structures. For example, in at least one embodiment of the invention, one or more of the blocks are implemented in software within a single (or multiple) digital processing device(s). The digital processing device(s) may include, for example, a general purpose microprocessor, a digital signal processor (DSP), a reduced instruction set computer (RISC), a complex instruction set computer (CISC), a field programmable gate array (FPGA), an application specific integrated circuit (ASIC), and/or others, including combinations of the above. Full hardware implementations, hardware/software hybrid implementations, and other implementations may also be used. As will be appreciated, many alternative communicator architectures may also be used in accordance with the present invention.

The receive antenna 12 is operative for receiving wireless signals from one or more remote base stations. The communication receivers 14, 16 may each be used to process communication signals from a corresponding one of the remote base stations. For example, at a particular time, receiver 14 may be configured to process signals received from an affiliated base station (i.e., a base station that is currently servicing the communicator 10) and receiver 16 may be configured to process signals from a candidate base station (i.e., a base station to which a handoff may subsequently occur).

The base stations to which the communication receivers 14, 16 correspond may change with time, particularly when the mobile communicator 10 is in motion. The communication receivers 14, 16 may include rake receiver functionality to process signals from corresponding base stations. The search receiver 18 searches for base stations within range of the mobile communicator 10 using signals received by the antenna 12. The search receiver 18 will also assemble information about the detected base stations and store this information within the base station memory 22. This information may then be used to select, for example, an appropriate base station for call handoff. During an active call, the mobile communicator 10 will normally report its search results to the network and let the network make any handoff decisions. The network then transmits the handoff information back to the mobile communicator 10. The handoff decision is normally autonomous during idle mode.

The user interface 24 provides for communication between the mobile communicator 10 and a user thereof. In this regard, the user interface 24 may include any of a wide variety of different input and output functionality including, for example, a speaker, a microphone, a keypad, a liquid crystal display or touch screen, data conversion functionality, and/or others. The specific types of functionality within the user interface 24 will typically depend upon the type of information being handled by the communicator 10 (e.g., data, voice, video, etc.). The controller 20 is operative for controlling the operation of the receivers 14, 16, 18 and the user interface 24 within the communicator 10. The controller 20 also controls the flow of information between the receivers and the user interface 24. As shown, the controller 20 will typically have access to the information within the base station memory 22 for use in performing control tasks (e.g., making handoff decisions, etc.).

The search receiver 18 searches for each base station of interest to the mobile communicator 10 within a corresponding time window (referred to hereinafter as a search window) associated with the base station. In past systems, a constant length search window was used to search for each individual base station. The search window size was typically dictated by the network for all base stations and would normally be constant throughout a large geographical area. Because the search window length was constant, it was usually based upon the worst case delay spread that was expected to exist within a channel between a base station and a mobile. In conceiving the present invention it was appreciated that, in a typical cellular system, worst case delay spread scenarios are relatively infrequent. Thus, in accordance with the present invention, an adaptable length search window is used within a mobile communicator (e.g., within search receiver 18 of Fig. 1) to search for a base station. That is, the length of the search window is allowed to change with time based on the changing condition of the corresponding channel. In general, the longer the search window that is used to search for a base station, the more system resources (e.g., time, energy, and/or computation resources) that are consumed to perform the search. By using a search window length that is more in line with current channel conditions, a significant reduction in system resource use may be achieved.

The search window for a base station will typically be defined with respect to a given reference point. The reference point for a base station may depend upon such things as the communication protocol being implemented and/or the current status of the base station within the mobile communicator 10. For example, in a system using an IS-95 or CDMA 2000 protocol, the base stations are synchronized and each transmits the same pilot sequence at a different phase offset from the other base stations. The pilot sequence is a known sequence transmitted through the common pilot channel. Mobile units use it to identify the bases and track the channel. Within the mobile, a number of different base station “sets” are typically defined including: an active set, a candidate set, a neighbor set, and a remaining set. The active set identifies one or more base stations (e.g., pilot offsets) that are currently being used for a call within the mobile. The candidate set identifies base stations that are not presently assigned to a call, but are strong enough to be used for a call. The neighbor set identifies base stations that are likely for handoff, but have not been “found” with sufficient quality by the search receiver. The remaining set identifies pilot offsets that exist in the system, and are not in the active, candidate or neighbor sets. In IS-95 or CDMA 2000, active and candidate sets typically use the earliest usable multipath component as the time reference for the search window. For neighbor bases, which might not have a usable path yet, there is a notion of system time, which is set according to a slow tracking of the earliest usable multipath component in the active and candidate set. The search window is then set according to the phase offset of the searched base, relative to the phase of the system time.

In the 3GPP wideband CDMA (WCDMA) system, each base station uses a unique spreading code. Thus, in such a system the search window may be centered about, for example, the earliest meaningful path received by the mobile communicator for the base station of interest (i.e., regardless of the status of the base station). Other techniques for determining the reference point of the search window are also possible. The principles of the present invention can be beneficially implemented regardless of the particular reference point selection technique that is used.

Fig. 2 is a block diagram illustrating functionality within a search receiver 26 in accordance with an embodiment of the present invention. For ease of illustration and to facilitate understanding, functionality is shown for use in searching for a single base station of interest. It should be appreciated, however, that similar functionality may be provided within a search receiver for each of a plurality of base stations of interest. As illustrated, the search receiver 26 includes: a searcher 28 having a variable search window size, a search window size controller 30, and a quality measure unit 32. The searcher 28 processes a received signal using a time-based search window associated with the corresponding base station. As described above, the search window will typically be defined with respect to a reference point associated with the base station. The search window size controller 30 is operative for varying the size of the search window used by the searcher 28 during device operation in a manner that is designed to reduce the use of system resources (on average) by the base station search function of the corresponding communicator. In at least one embodiment, the search window size controller 30 occasionally (e.g., periodically) changes the search window size of the searcher 28 to a “full” window size to determine, for example, a present channel condition between the corresponding base station and the communicator. The “full” window size may be selected based upon a worst case delay spread that is expected in the channel. The search window size controller 30 then determines a search window size for the searcher 28 for subsequent search activity based on the result of the full window search. Thus, the size of the search window adapts based on the changing condition of the channel.

The quality measure unit 32 is operative for determining and tracking a quality measure of the associated base station, based on the output of the searcher 28. In a system using CDMA, for example, the quality measure unit 32 may use the information output by the searcher 28 to derive relative strength information for the corresponding base station. Other quality measures may alternatively be tracked. The quality measure information determined by the quality measure unit 32 may then be stored within a memory unit for subsequent use (e.g., base station memory 22 of Fig. 1).

Figs. 3 and 4 are portions of a flowchart illustrating a process 34 for searching for a base station using an adaptable length search window in accordance with an embodiment of the present invention. The process 34 (as well as the other processes described below) may be practiced within, for example, the mobile communicator 10 of Fig. 1 as well as in communicators having other architectures. The process 34 may be performed for each base station being searched by a particular communicator. In general, the process 34 uses a small search window size (SMALL) during normal operation. The small search window size is preferably selected to encompass most of the delay spread scenarios that are possible between the base station and the mobile (i.e., not worst case scenarios). Occasionally, a search is performed using a full search window size (FULL). As described above, this full search window size may be selected based upon a worst case delay spread that is expected in the channel between the base station and the mobile. The result of the full window search is used to determine whether significant energy exists outside of the small search window size for the base station. If significant energy does exist outside the small search window size, subsequent searching is performed at the larger search window size. If significant energy does not exist outside of the small search window size, subsequent searching is performed at the small search window size. In one approach, significant energy is considered to exist outside the small search window size when one or more paths of a multipath channel are detected outside the small search window that have magnitudes exceeding a predetermined threshold level. In another approach, significant energy is considered to exist outside the small search window size when the sum of the energies of all the detected paths outside the small search window exceeds a predetermined threshold level.

Referring now to Fig. 3, the search window size (WINDOW) that will be used to search for the base station is set to SMALL (block 36). A time counter is then initialized to zero or some other reference value (block 38). A search is next performed for the base station using the current search window size (block 40). The search is then repeated until the time counter has reached a predetermined value T (block 42). It should be appreciated that the value of T may be modified over time based on one or

more variables (e.g., mobile speed, etc.). With reference to Fig. 4, it is next determined whether the current search window size is equal to FULL (block 44). Because the search window size is not equal to FULL at this point in the process, the search window size is changed to FULL (block 46) and a full window search is performed (block 48).

5 It is next determined whether any significant receive energy has been detected for the base station outside of the small search window during the full window search (block 50). If no such energy has been detected, the search window size is changed back to SMALL (block 52). If energy has been detected outside of the small search window, the search window remains at FULL (block 54). The process 34 is then repeated using
10 the updated search window size (i.e., either SMALL or FULL). The time counter is again initialized (block 38) and searches are performed using the updated search window size until the time counter has again reached T (blocks 40 and 42).

At this point, it is again determined whether the current search window size is FULL (block 44). If not, the search window size is changed to FULL (block 46),
15 another search is performed (block 48), and it is determined whether any significant receive energy has been detected outside of the small search window (block 50). If the latest search window size is FULL, on the other hand, it is immediately determined whether any significant receive energy has been detected outside of the small search window (e.g., using the last search during interval T). As before, if no energy has been
20 detected outside of the small search window, the search window size is changed to SMALL (block 52), otherwise the search window remains at FULL (block 54). The process 34 then repeats as described above.

Instead of checking the status of the current search window in block 44, a full window search (e.g., blocks 46 and 48) may be performed for each cycle of the process
25 34, regardless of current search window size. As described above, in the illustrated embodiment, the decision to change to the small search window size is made based upon the single full window search of block 48. In an alternative approach, the decision to change to the small search window size is made only after N consecutive full window searches do not find significant energy outside the small search window.
30 In this manner, the chances of changing to the small search window size based on a

temporary reduction in detected energy caused by momentary fading, is reduced. In one embodiment of the invention, the method 34 of Figs. 3 and 4 is modified by starting the process at block 46 (initializing the search window to FULL) and by ignoring the search window initialization of block 36. Thus, the search receiver will first check the full search window for energy outside the small search window and then change to the small search window if no significant energy is detected.

Figs. 5 and 6 are portions of a flowchart illustrating a process 80 for searching for a base station using an adaptable length search window in accordance with another embodiment of the present invention. With reference to Fig. 5, the search window size is set to FULL (block 84) and a full window search is performed for the base station (block 86). A new search window size is next determined based on the results of the full window search (block 88). This determination can be made in any of a variety of ways. In one approach, for example, a delay spread of the channel is estimated using the results of the full window search. A smallest search window size may then be found that will encompass all significant energy within the estimated delay spread. The smallest search window size may be selected, for example, from a plurality of predefined search window sizes. Alternatively, the smallest search window size may be directly calculated by the earliest and latest usable detected paths. As will be appreciated, other techniques for determining a new search window size may also be used. As before, the decision to change to a new search window size may alternatively be based upon a plurality of consecutive full window searches. Also, the initial search window size of block 84 may be given a variety of sizes, based on speed, time, in a cyclic fashion, based on the results of previous searches, or a combination thereof. After the new search window size has been determined, the search window is set accordingly (block 90) and a time counter is initialized (block 92). With reference to Fig. 6, searches are then performed until the time counter has reached a value of T (blocks 94 and 96). The process 80 is then repeated. As before, the value of T may change over time based on, for example, one or more variables.

It should be appreciated that other variables may also effect the determination of the new search window size, in addition to the results of the full window search. This

may include, for example, cell size (e.g., macro, micro, or pico cell). Typically, a larger cell size will result in a larger delay spread. Usage of repeaters can also influence this parameter. These other variables may be taken into account in the search window size determination in accordance with the present invention.

5 In the processes described above, a time counter approach is used to limit a period during which searches are performed for a base station using a particular search window size. It should be appreciated that other means of limiting such a period may also be used. For example, in one alternative approach, a predetermined number of searches is performed using the corresponding search window size before subsequent
10 processing is undertaken. In another alternative approach, a large change in the measured channel conditions can interrupt the normal process of search window size setting, and ignite a new evaluation of the search window size. Other techniques are also possible.

 Although the present invention has been described in conjunction with certain
15 embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention as those skilled in the art readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and the appended claims.

What is claimed is:

- 1 1. A mobile communicator comprising:
2 a search receiver to search for a base station using a search window size that
3 adapts over time based on a changing channel condition between the base station and
4 the mobile communicator.
- 1 2. The mobile communicator of claim 1, wherein:
2 said search receiver uses a first search window size to search for the base station
3 during normal operation and changes to a second, larger search window size to search
4 for the base station when received energy is detected outside of said first search
5 window size for the base station.
- 1 3. The mobile communicator of claim 2, wherein:
2 said first search window size is selected to encompass a majority of possible
3 delay spread conditions between the base station and the mobile communicator.
- 1 4. The mobile communicator of claim 1, wherein said search receiver includes:
2 a searcher having a variable size search window; and
3 a search window size controller to control the search window size of the
4 searcher, said search window size controller to occasionally change the search window
5 size of the searcher to a full search window size for use in determining a present
6 channel condition between the base station and the mobile communicator.
- 1 5. The mobile communicator of claim 4, wherein:
2 said search window size controller determines a subsequent search window size
3 for the searcher based on the present channel condition.
- 1 6. The mobile communicator of claim 4, wherein:
2 said full search window size is related to an expected worst case delay spread in
3 the channel between the base station and the mobile communicator.

1 7. The mobile communicator of claim 4, wherein:
2 said search window size controller estimates a delay spread of the channel
3 between the base station and the mobile communicator and determines a subsequent
4 search window size for the searcher based on the estimated delay spread.

1 8. The mobile communicator of claim 7, wherein:
2 said search window size controller determines a smallest search window size
3 that encompasses all significant paths within the estimated delay spread of the channel.

1 9. The mobile communicator of claim 7, wherein:
2 said search window size controller selects the subsequent search window size
3 from a plurality of predetermined search window sizes.

1 10. The mobile communicator of claim 4, comprising:
2 a quality measure unit to determine a quality measure for the base station using
3 an output of the searcher.

1 11. The mobile communicator of claim 1, wherein:
2 said search receiver searches for multiple base stations using corresponding
3 search window sizes that adapt over time based on changing channel condition between
4 each corresponding base station and the mobile communicator.

1 12. A method for searching for a base station from a mobile communicator,
2 comprising:
3 searching for the base station using a search window; and
4 adapting a size of the search window over time based on a changing channel
5 condition between the base station and the mobile communicator.

1 13. The method of claim 12, wherein:
2 adapting a size of the search window includes:
3 occasionally searching for the base station using a full search window
4 size; and
5 changing the search window size based on a result of one or more full
6 search window searches.

1 14. The method of claim 12, wherein:
2 adapting a size of the search window includes:
3 estimating a delay spread of a channel between the base station and the
4 mobile communicator; and
5 selecting a smallest search window size that encompasses the estimated
6 delay spread.

1 15. The method of claim 12, wherein:
2 adapting a size of the search window includes:
3 determining whether receive energy has been detected outside a first
4 search window size; and
5 changing the size of the search window to the first search window size
6 when receive energy has not been detected outside said first search window
7 size.

1 16. A method for searching for a base station from a mobile communicator,
2 comprising:
3 searching for the base station using a first search window size;
4 occasionally checking for significant received energy outside of said first search
5 window size for the base station; and
6 searching for the base station for a predetermined period using a second search
7 window size that is greater than said first search window size when significant received

8 energy is detected outside of said first search window size during occasionally
9 checking.

1 17. The method of claim 16, wherein:
2 occasionally checking for significant received energy outside of said first search
3 window size includes searching for the base station using a full search window size that
4 is greater than said first search window size.

1 18. The method of claim 17, wherein:
2 said first search window size is a size that is expected to encompass a majority
3 of possible delay spread conditions in a channel between the base station and the
4 mobile communicator; and
5 said full search window size is a size that is expected to encompass a worst case
6 delay spread condition in the channel between the base station and the mobile
7 communicator.

1 19. The method of claim 17, wherein:
2 said second search window size is equal to said full search window size.

1 20. The method of claim 17, wherein:
2 said second search window size is less than or equal to said full search window
3 size.

1 21. The method of claim 16, wherein:
2 occasionally checking includes checking at regular intervals.

1 22. The method of claim 16, wherein:
2 occasionally checking includes estimating a delay spread for the channel
3 between the base station and the mobile communicator; and

4 said second search window size is determined based upon the estimated delay
5 spread.

1 23. A mobile communicator that is programmed to search for one or more base
2 stations using the method of claim 16.

1 24. A method for searching for a base station from a mobile communicator,
2 comprising:

3 first searching for the base station using a large search window size;
4 determining a new search window size to search for the base station based on a
5 result of said first searching; and
6 second searching for the base station using the new search window size.

1 25. The method of claim 24, wherein:
2 second searching includes searching for the base station using the new search
3 window size for a first time duration.

1 26. The method of claim 25, further comprising:
2 repeating first searching, determining, and second searching after said first time
3 duration has elapsed.

1 27. The method of claim 26, further comprising:
2 adapting a length of said first time duration over time based on a predetermined
3 criterion.

1 28. The method of claim 24, wherein:
2 determining a new search window size includes selecting one of a plurality of
3 predetermined search window sizes.

1 29. The method of claim 24, wherein:
2 determining a new search window size includes determining a size that will
3 encompass a delay spread associated with the base station.

1 30. The method of claim 24, wherein:
2 determining a new search window size includes:
3 determining whether significant received energy was detected during
4 said first searching that was outside of a first search window, said first search
5 window having a size that is smaller than said large search window size; and
6 setting the new search window size equal to the size of the first search
7 window when significant received energy was not detected outside of said first
8 search window.

1 31. A mobile communicator that is programmed to search for one or more base
2 stations using the method of claim 24.

ABSTRACT

A search receiver in a mobile communicator uses an adaptable search window to search for one or more base stations.

"Express Mail" mailing label number: EV019077315US

Date of Deposit: January 15, 2002

This paper or fee is being deposited on the date indicated above with the United States Postal Service pursuant to 37 CFR 1.10, and is addressed to the Commissioner for Patents, Box Patent Application, Washington, D.C. 20231.

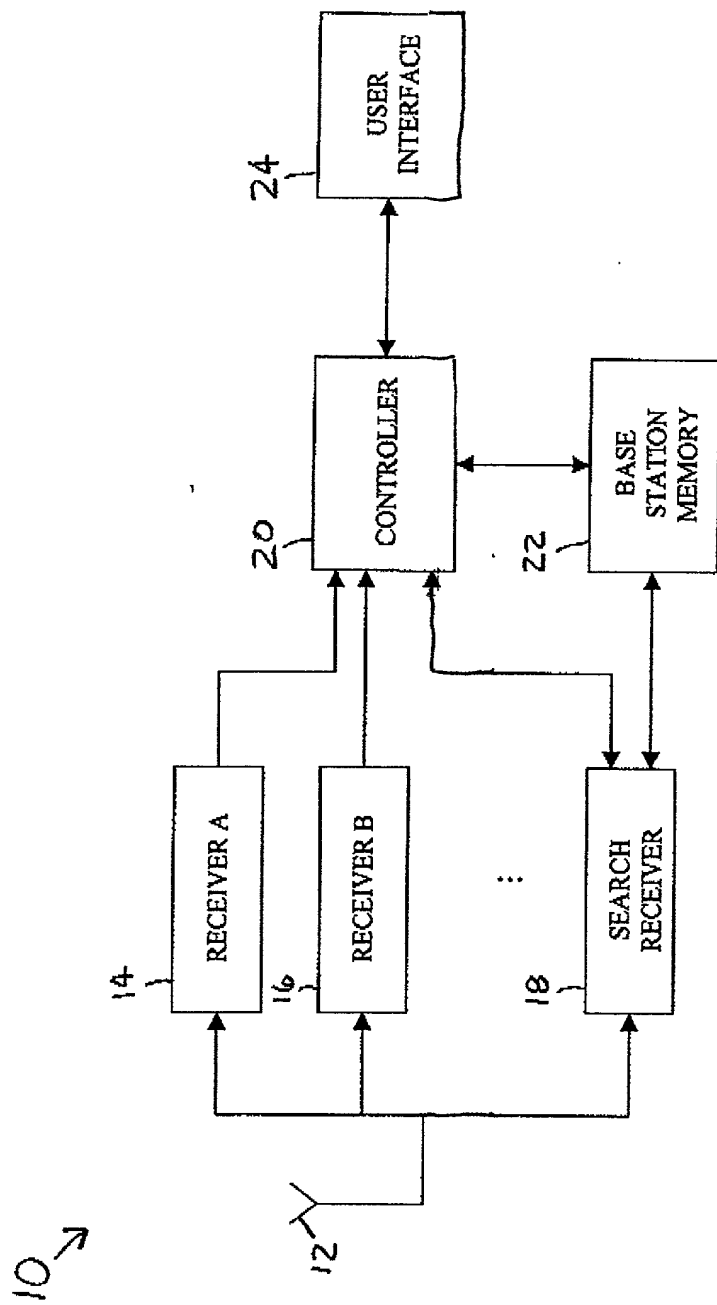


Fig. 1

26 →

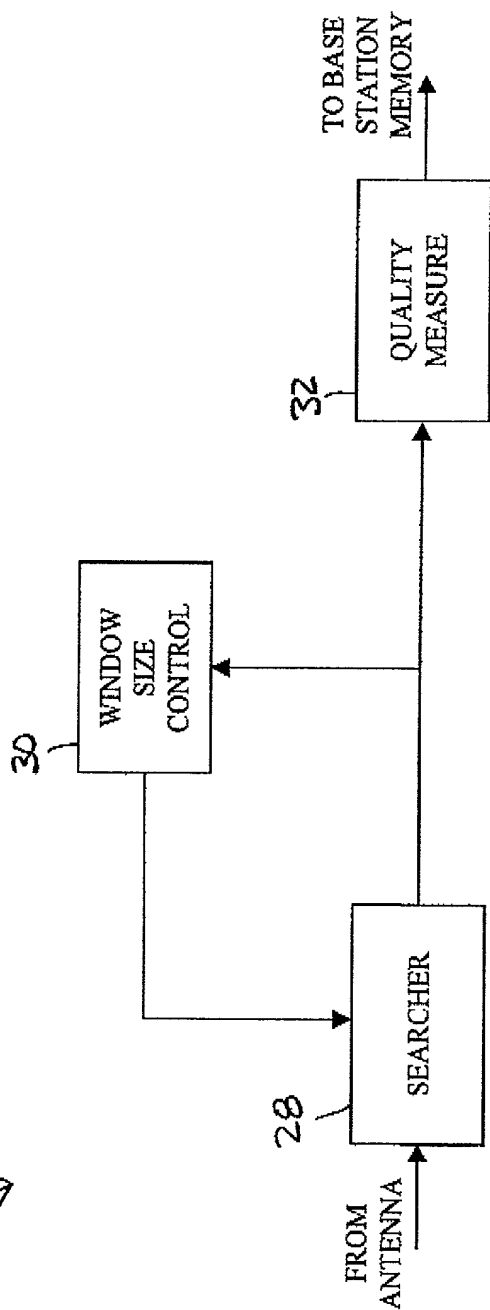


Fig. 2

34
↓

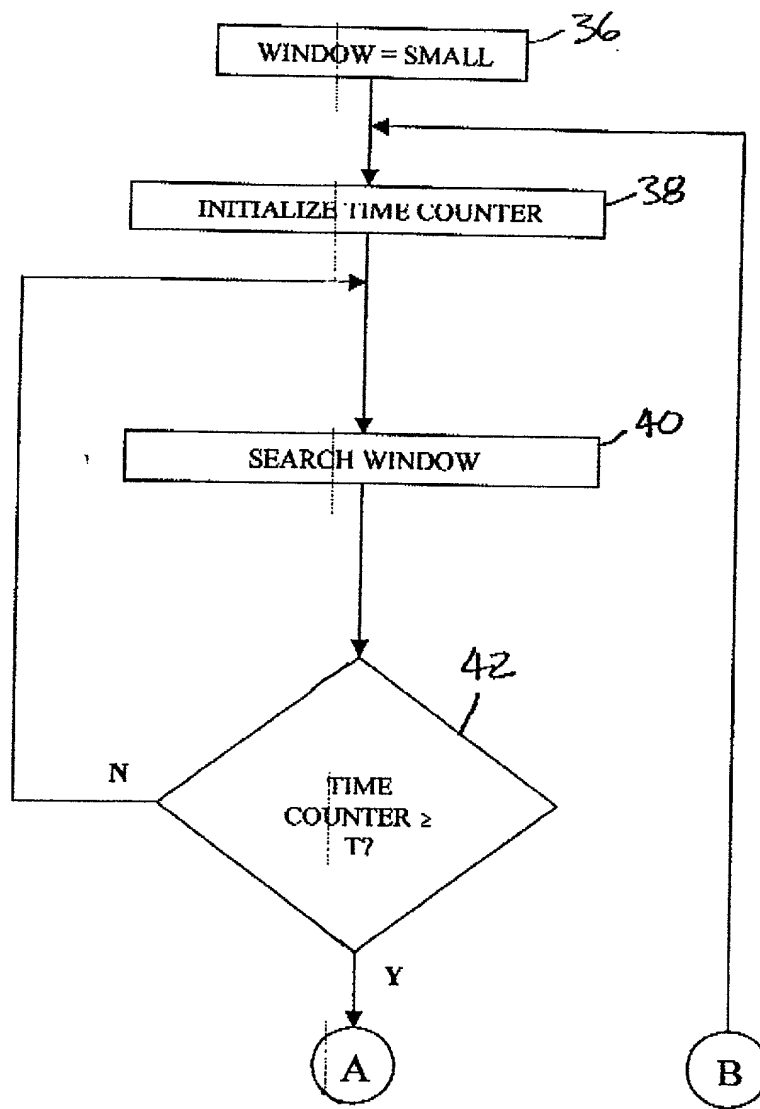


Fig. 3

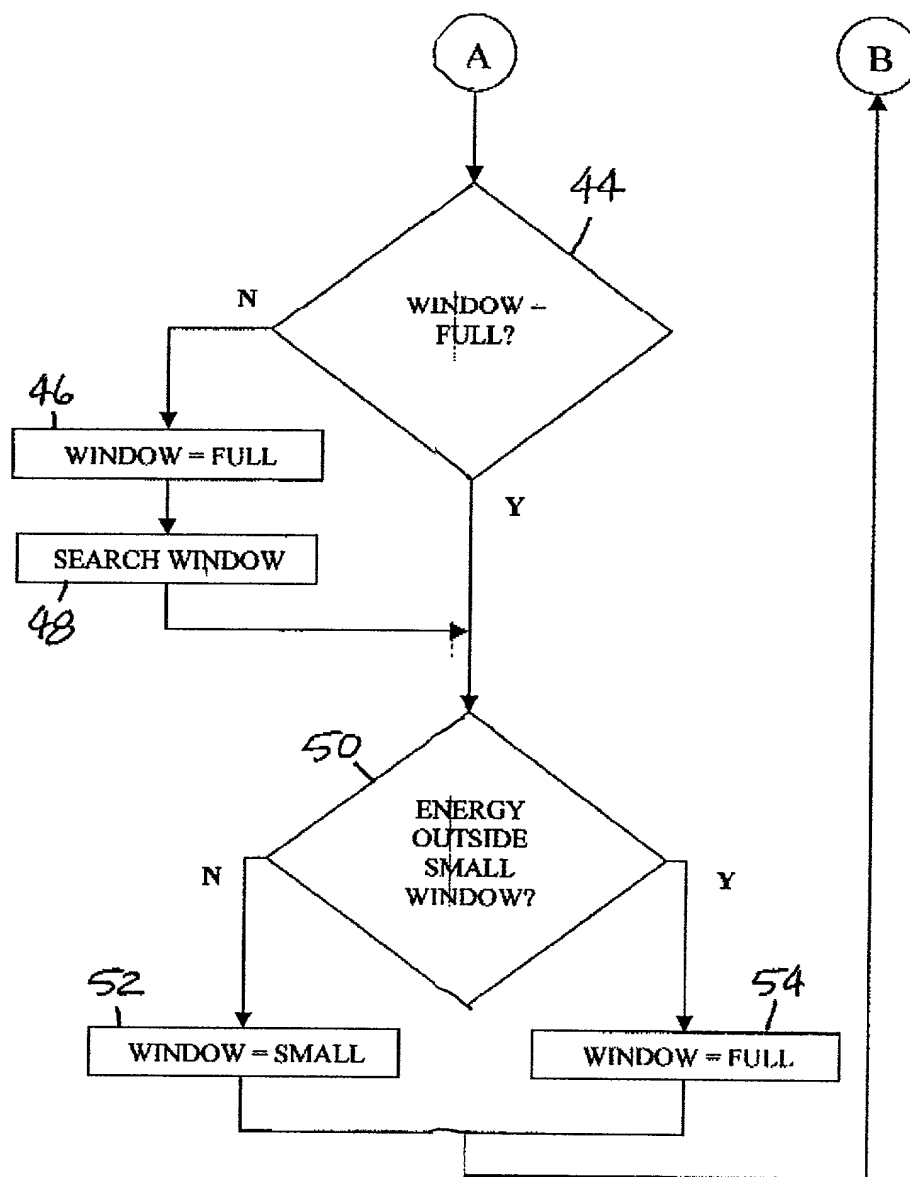


Fig. 4

80
↓

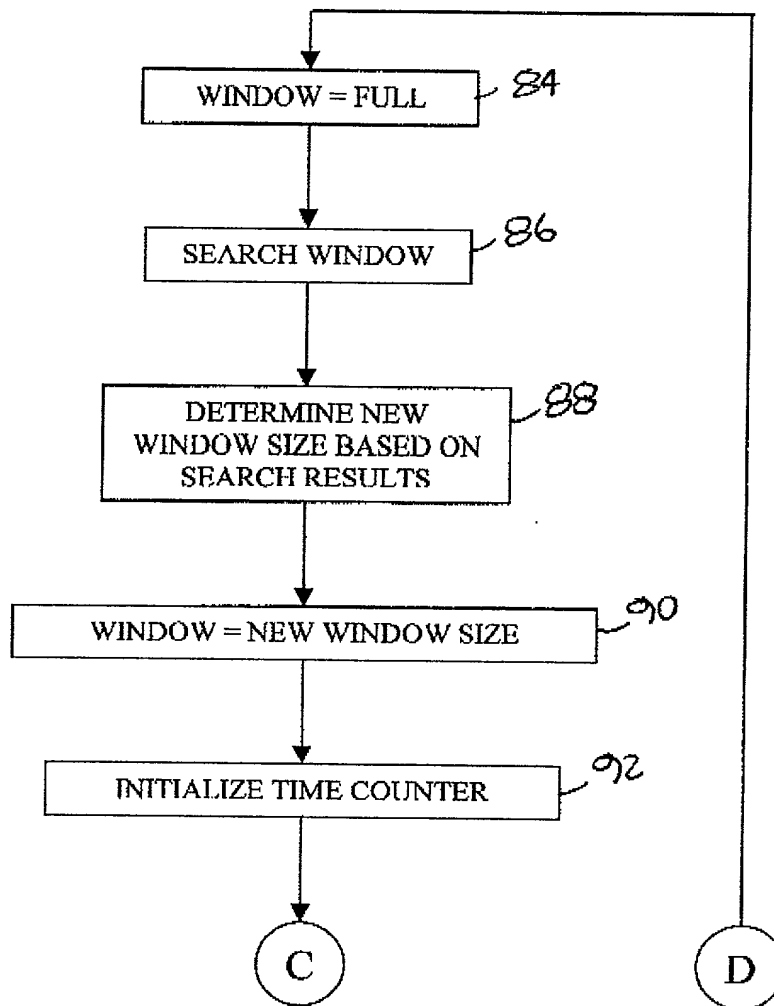


Fig. 5

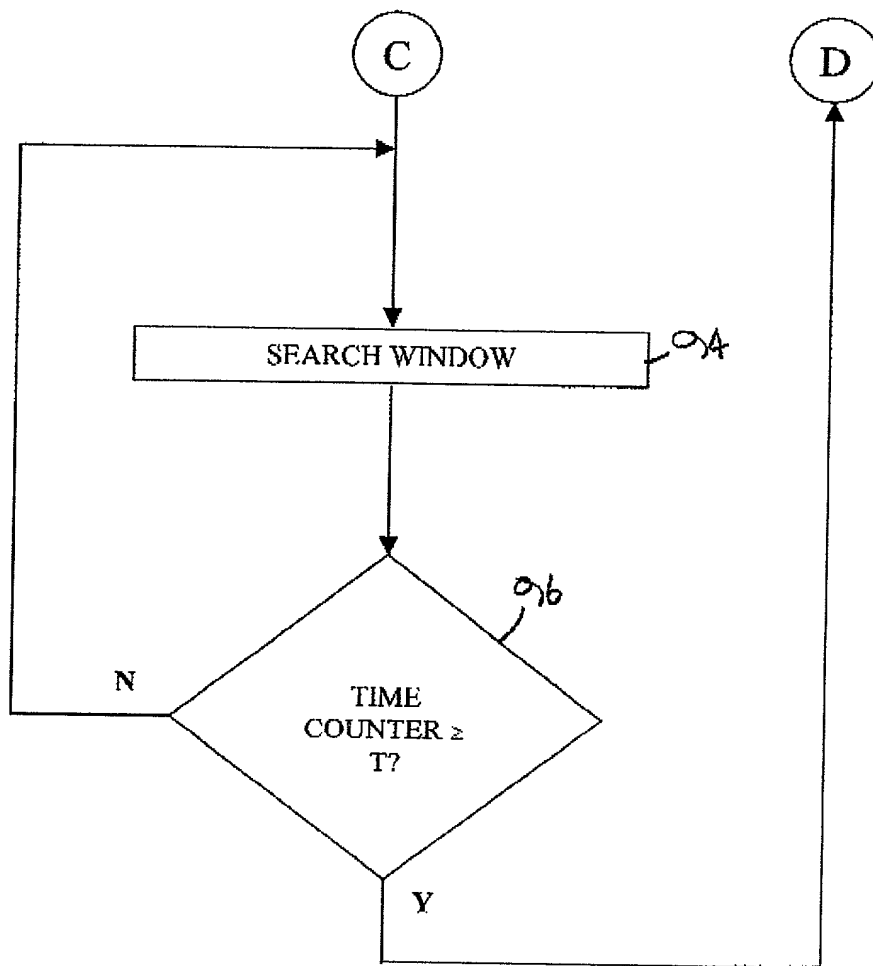


Fig. 6

SCHWEGMAN ■ LUNDBERG ■ WOESSNER ■ KLUTH

United States Patent Application
COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled: METHOD AND APPARATUS FOR SEARCHING FOR A BASE STATION USING AN ADAPTABLE SEARCH WINDOW.

The specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 C.F.R. § 1.56 (attached hereto). I also acknowledge my duty to disclose all information known to be material to patentability which became available between a filing date of a prior application and the national or PCT international filing date in the event this is a Continuation-In-Part application in accordance with 37 C.F.R. § 1.63(e).

I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed:

No such claim for priority is being made at this time.

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below:

No such claim for priority is being made at this time.

I hereby claim the benefit under 35 U.S.C. § 120 or 365(c) of any United States and PCT international application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT international application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose material information as defined in 37 C.F.R. § 1.56(a) which became available between the filing date of the prior application and the national or PCT international filing date of this application:

No such claim for priority is being made at this time.

I hereby appoint the following attorney(s) and/or patent agent(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith:

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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§ 1.56 Duty to disclose information material to patentability.

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclose information exists with respect to each pending claim until the claim is canceled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is canceled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclose all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§ 1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

- (1) prior art cited in search reports of a foreign patent office in a counterpart application, and
- (2) the closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made of record in the application, and

- (1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or
- (2) It refutes, or is inconsistent with, a position the applicant takes in:
 - (i) Opposing an argument of unpatentability relied on by the Office, or
 - (ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

- (1) Each inventor named in the application;
- (2) Each attorney or agent who prepares or prosecutes the application; and
- (3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.